

## Abstract

### CAMMP TEAM

The International Space Station (ISS) Configuration Analysis Modeling and Mass Properties (CAMMP) Team is presenting a demo of certain CAMMP capabilities at a Booz Allen Hamilton conference in San Antonio.

The team will be showing pictures of low fidelity, simplified ISS models, but no dimensions or technical data. The presentation will include a brief description of the contract and task, description and picture of the Topology, description of Generic Ground Rules and Constraints (GGR&C), description of Stage Analysis with constraints applied, and wrap up with description of other tasks such as Special Studies, Cable Routing, etc.

The models include conceptual Crew Exploration Vehicle (CEV) and Lunar Lander images and animations created for promotional purposes, which are based entirely on public domain conceptual images from public NASA web sites and publicly available magazine articles and are not based on any actual designs, measurements, or 3D models. Conceptual Mars rover and lander are completely conceptual and are not based on any NASA designs or data.

The demonstration includes High Fidelity Computer Aided Design (CAD) models of ISS provided by the ISS 3D CAD Team which will be used in a visual display to demonstrate the capabilities of the Teamcenter Visualization software. The demonstration will include 3D views of the CAD models including random measurements that will be taken to demonstrate the measurement tool.

A 3D PDF file will be demonstrated of the Blue Book fidelity assembly complete model with no vehicles attached. The 3D zoom and rotation will be displayed as well as random measurements from the measurement tool.

The External Configuration Analysis and Tracking Tool (ExCATT) Microsoft Access Database will be demonstrated to show its capabilities to organize and track hardware on ISS. The data included will be part numbers, serial numbers, historical, current, and future locations, of external hardware components on station. It includes dates of all external ISS events and flights and the associated hardware changes for each event. The hardware location information does not always reveal the exact location of the hardware, only the general location. In some cases the location is a module or carrier, in other cases it is a WIF socket, handrail, or attach point. Only small portions of the data will be displayed for demonstration purposes.



# *CAMMP Team*

*October 3, 2008*



*CAMMP Team*

*ISS Strategic Planning, Assembly, Requirements, & Configuration*

*[http://saber.jsc.nasa.gov/team\\_cammp](http://saber.jsc.nasa.gov/team_cammp)*



Booz | Allen | Hamilton





# *Purpose*

## **Purpose**

- ***To provide community awareness of the expanded Configuration Analysis Modeling & Mass Properties (CAMMP) products, tools & services***

## **Agenda**

- ***CAMMP Team Background***
- ***Services***
- ***Tools***
- ***Products***



# *CAMMP Team Background*

- **Part of PI&C contract**
  - ◆ OM2 – Strategic Planning, Assembly, Requirements, & Configuration
  - ◆ OM2 Manager – Joe LaRoche
  - ◆ Vehicle Configuration Team Lead – Linda Jack
- **Supports OM by tracking, documenting, and analyzing current and future external and assembly level configurations of ISS**
- **Chairs the Configuration Working Group (CWG)**
  - ◆ Currently scheduled on Tuesdays as needed
  - ◆ External configuration issues should be brought forward to the CWG to ensure the clearance or integrated issues are solved (see process in backup charts)
  - ◆ Results reported to VSP (VIPER SPARC Panel) and PICB, if necessary
- **Team Members**
  - ◆ Abigail De Los Reyes (Lead), Bill Hahn, David Kin, Alex Osorio, Alun Wann, Shonn Everett
- **Website:** [http://saber.jsc.nasa.gov/team\\_cammp](http://saber.jsc.nasa.gov/team_cammp)



# *CAMMP Services, Tools, & Products*

- **Services**

- ◆ 3D CAD Modeling and 2D Drawings
- ◆ Aerodynamic and Mass Properties Analysis
- ◆ Clearance Analysis and Clearance Envelopes (Keep Out Zones, Field Of View)
- ◆ Conceptual Graphic Design Generation, Animation, and Visualization

- **Tools**

- ◆ CAD packages
  - PRO/E
  - Adobe Acrobat 3D
  - VisView
  - I-DEAS
  - Enigma
- ◆ ExCATT (External Configuration Analysis and Tracking Tool)
- ◆ Math Modeling with MathCAD

- **Products**

- ◆ Assembly Matrix
- ◆ “Blue Book” – The On-Orbit Assembly, Modeling, and Mass Properties Data Book (JSC 26557)
- ◆ ISS Reference Coordinate Systems Document (SSP 30219)
- ◆ ISS On-Orbit ICD (Section 3) / VC JTWG Data Source Letters and Orbiter
- ◆ ExCATT Reports



# *Services*

- **The CAMMP team provides**
  - ◆ 3D CAD modeling and 2D drawings
  - ◆ Aerodynamic and mass properties for ISS configurations
  - ◆ Clearance Analysis and Clearance Envelopes (Keep Out Zones, Field Of View)
  - ◆ Conceptual Graphic Design Generation, Animation, and Visualization
- **Requests are documented in the form of Action Items (located on CAMMP website)**
  - ◆ Request form available on website
  - ◆ Website: [http://saber.jsc.nasa.gov/team\\_cammp/ActionItems.php](http://saber.jsc.nasa.gov/team_cammp/ActionItems.php)
- **Data/models for analysis are supplied by**
  - ◆ Boeing ISS 3D CAD Model Team (data source for CAD models)
  - ◆ OM2/Strategic Planning, Assembly, Requirements & Configuration
  - ◆ MOD (EVA, Robotics, Design Integration)
  - ◆ RIP EVA Splinter (OC, XA)
  - ◆ OZ/Payloads
- **Primary Customer is the Program Integration office (external configuration studies)**
  - ◆ Additional customers - Boeing VIPER and GN&C



## *Services (Cont'd)*

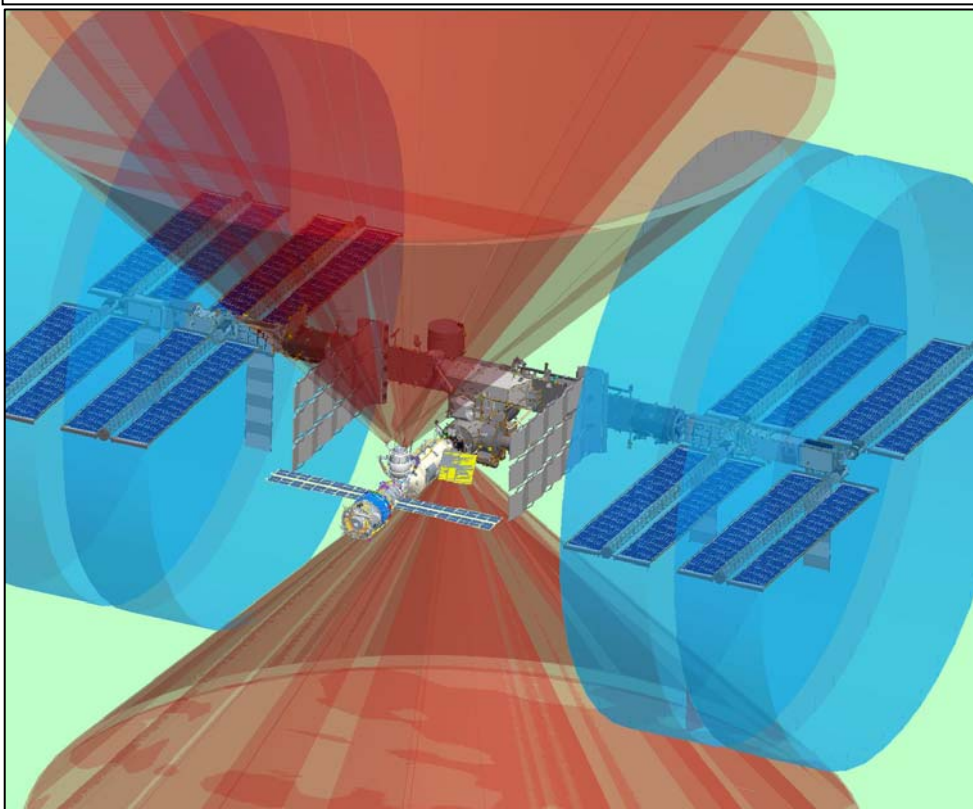
- ***Visview capture***



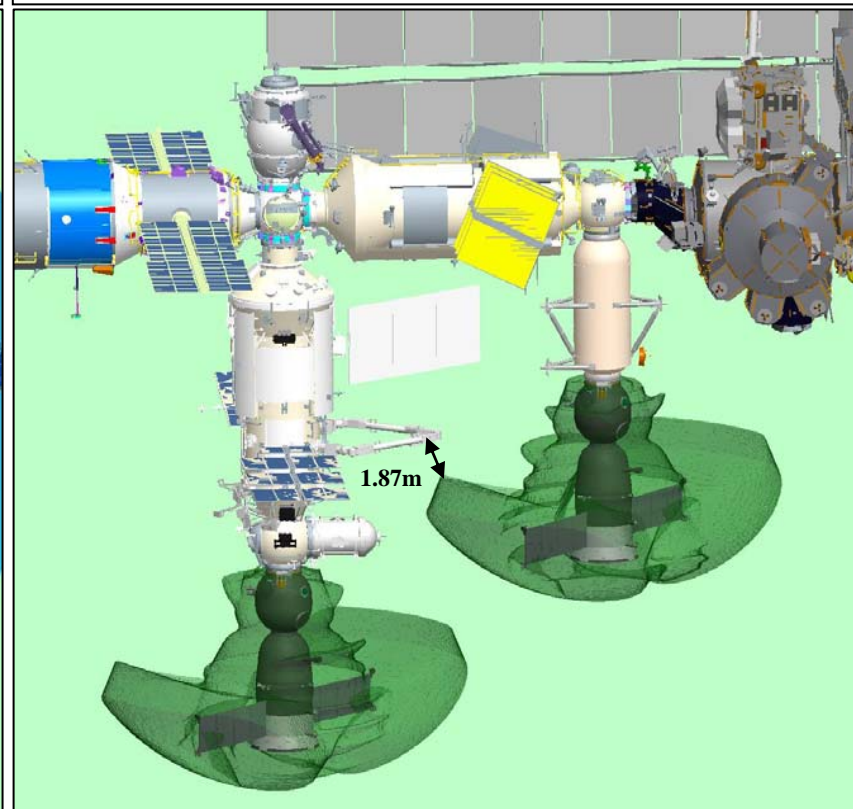
## *Services (Cont'd)*

- ***Clearance analysis with Static and Dynamic Envelopes (Pro/E)***

DC1 and FGB Kurs with Solar Array Static Envelopes



Dynamic Envelope of Soyuz



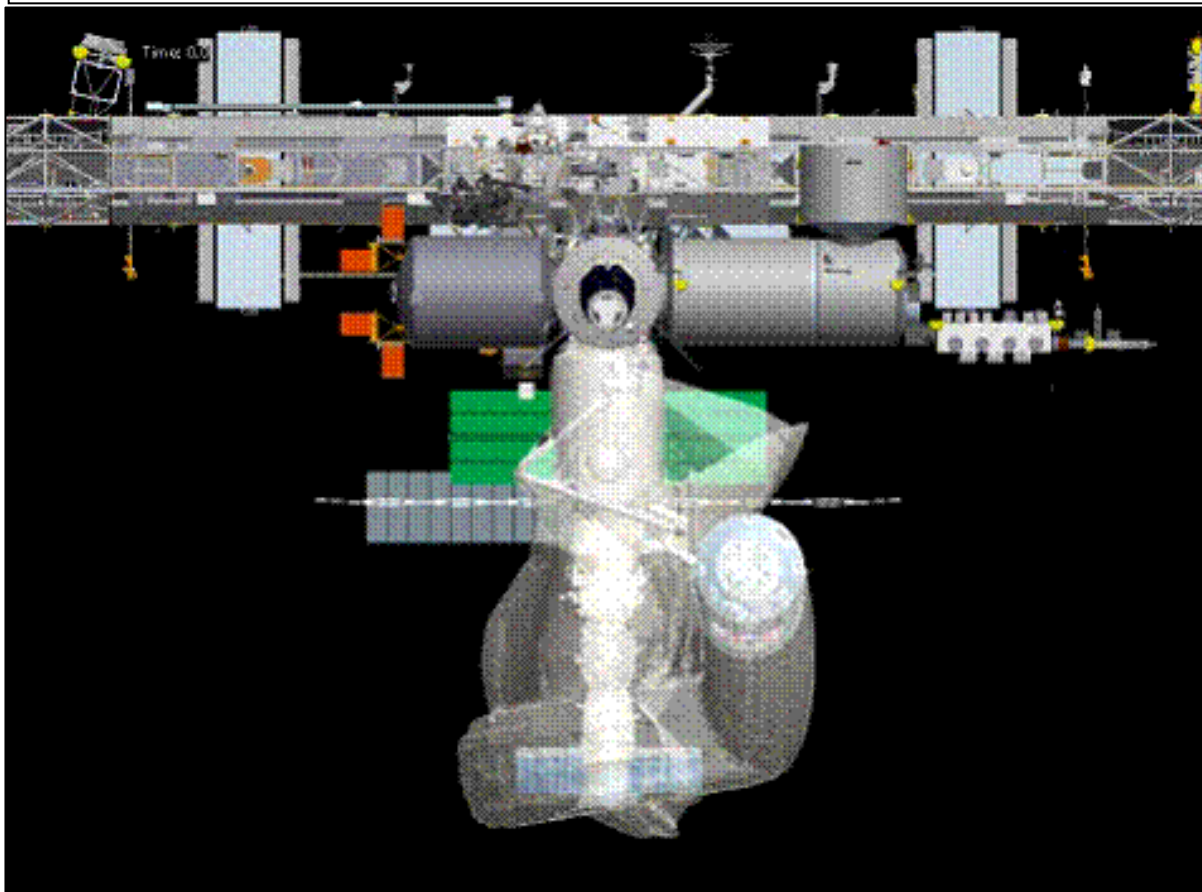




## *Services (Cont'd)*

- ***Motion Envelopes (Pro/E)***

HTV Berthing to Node 2 Nadir

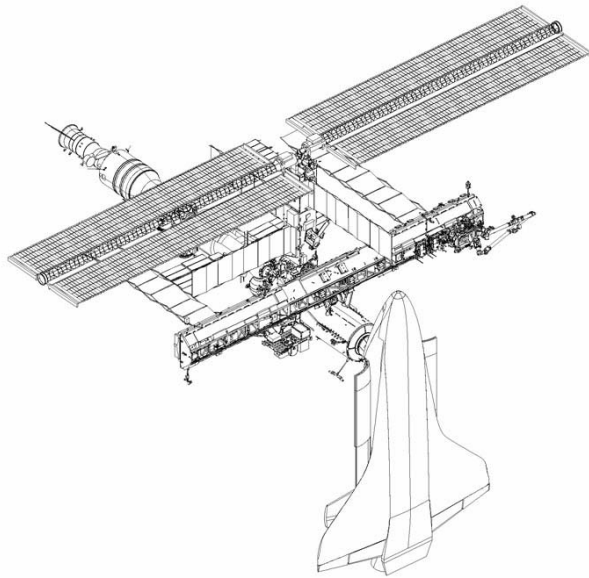




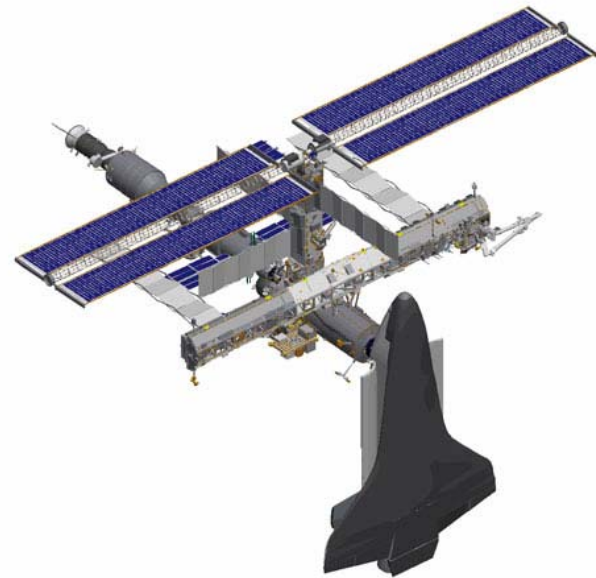
## *Services (Cont'd)*

- ***Line and shaded 2D drawings (Pro/E)***

Line



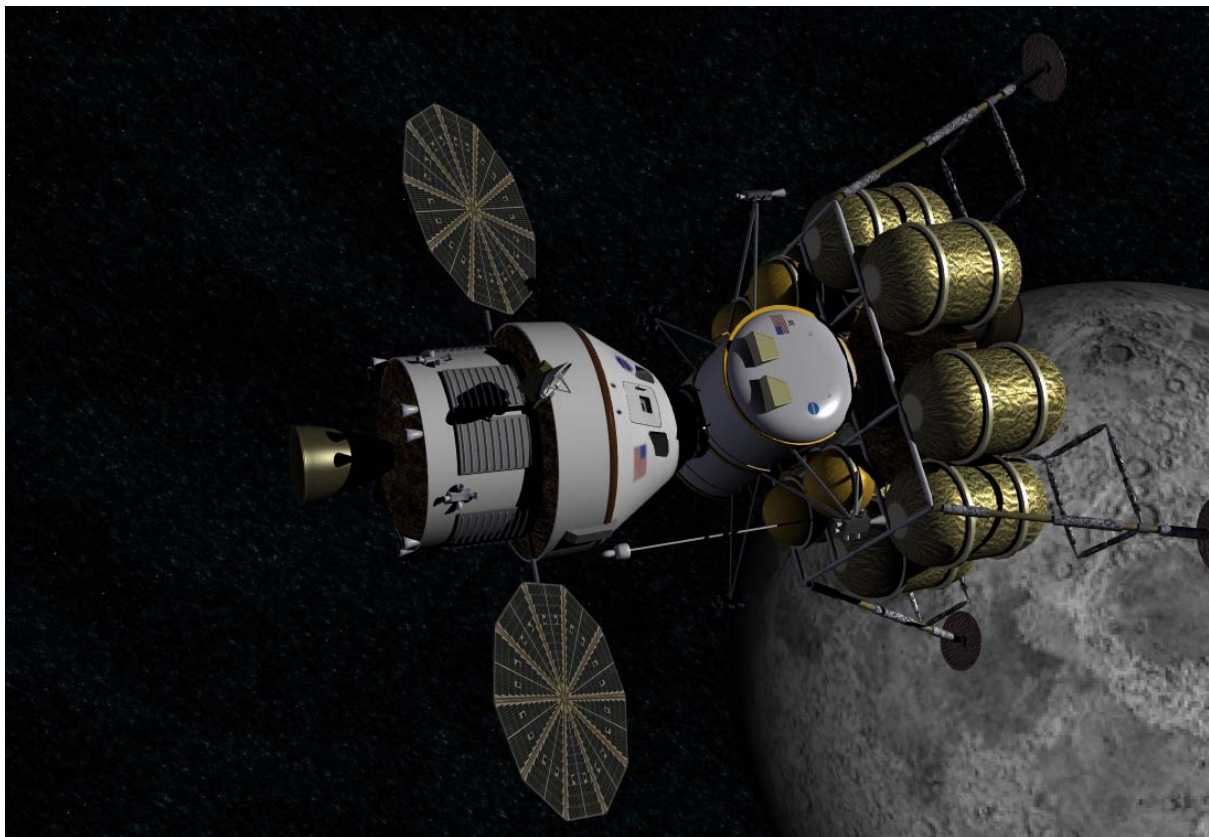
Shaded





## *Services (Cont'd)*

- **Conceptual Graphic Design Visualization (*Enigma*)**
- ***CEV and conceptual lander***





# Tools

## ● **CAD capability**

- ◆ *CAD packages are the major tools used to produce the ISS, Orbiter, and mated assembly models, geometries, drawings, and mass properties data files*
- ◆ *CAD software packages available in the CAMMP Lab: Pro/E, VisView, IDEAS, Adobe Acrobat 3D*
  - *Pro/E generates all line, shaded, and four view drawings and is used for clearance analysis*
  - *Adobe Acrobat 3D provides the ability to export models as a .pdf for users to view the ISS models/configurations in 3D (using Adobe Acrobat Reader 8.1 or later)*
  - *VisView allows use of high fidelity models for clearance analysis*
  - *IDEAS is the primary software for calculation of mass properties for each external configuration change*
  - *Enigma provides fast prototyping, 3D modeling/rendering/animation, and model format conversion*

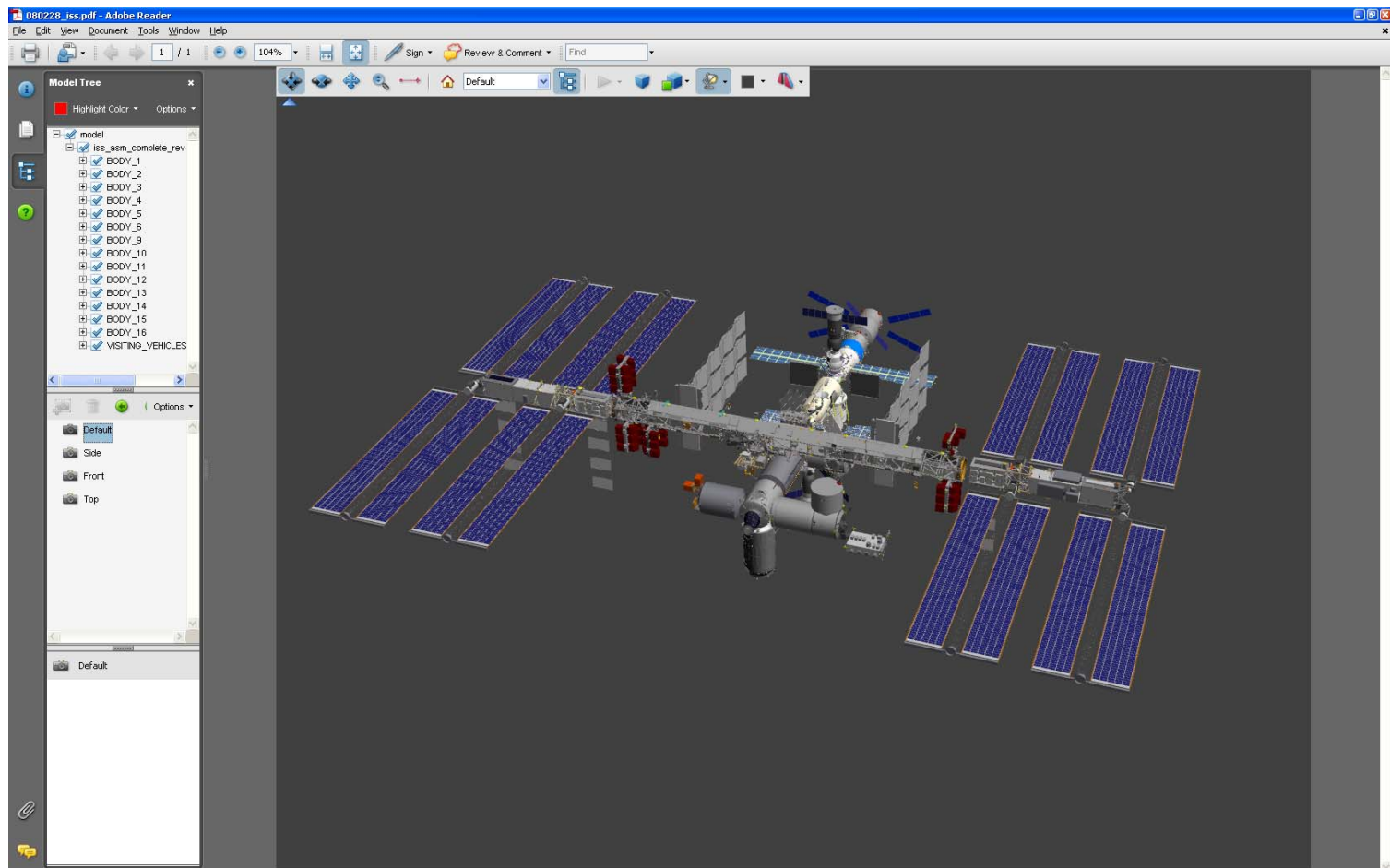
## ● **In-house tools**

- ◆ *Generate electronic data files formatted for GN&C and Blue Book to fit customer requirements from the IDEAS generated mass property reports*
- ◆ *Verify mass property reports for Blue Book*
- ◆ *Pro/E is used in combination with ImageJ to calculate projected area and center of pressure used by GN&C*



## *Tools (Cont'd)*

- ***Adobe Acrobat 3D screen capture***







## *Tools (Cont'd)*

- ***ExCATT (External Configuration Analysis and Tracking Tool)***
  - ◆ *Reference tool to track and report external configurations of the ISS*
  - ◆ *Requires coordination with MER to obtain external configuration changes before and after each Shuttle mission (See backup charts for process)*
  - ◆ *Populated with data from strategic timeframe (from Assembly Matrix) to track future events*
  
- ***Math Modeling with MathCAD***
  - ◆ *Precise and Explicit Math Modeling and Calculations*
  - ◆ *Simulation and Verification*
  - ◆ *Data Handling and Processing*
  - ◆ *Interface with Excel and Pro/E*
  - ◆ *Report Writing*

### ***Pitch-Yaw-Roll Transformation Matrix***

$$\mathbf{C_p \cdot C_y \cdot C_r} := \begin{pmatrix} \cos(p) \cdot \cos(y) & \sin(p) \cdot \sin(r) + \dots & \dots \\ -\sin(y) & \cos(r) \cdot \dots & \dots \\ \sin(p) \cdot \cos(y) & \sin(p) \cdot \cos(r) \cdot \sin(y) - \dots & \dots \end{pmatrix}$$



# *Products*

- **Assembly Matrix**

- ◆ *Documents ISS assembly configuration stages that affect mass and aerodynamic properties of ISS*
  - *First step in the development of “The Blue Book” (On-Orbit Assembly, Modeling, and Mass Properties Data Book)*
- ◆ *Delivered semi-annually, end of February and August*
  - *Captures ISS Configurations through Assembly Complete, including Flight 3R (MLM)*
  - *Deliverable to Boeing Mass Properties & Assembly Integration team to obtain mass property data*
- ◆ *Tasks to populate Assembly Matrix obtained through various ISS organizations from documents such as:*
  - *IDRD*
  - *MIM*
  - *RIP EVA Splinter Task Matrix*



## *Products (Cont'd)*

- **Blue Book (JSC 26557)**
  - ◆ *Provides comprehensive mass and aerodynamic properties data for the full range of ISS assembly tasks*
    - *Primarily addresses assembly sequence and tasks*
    - *Blue Book CAD models reflect task sequence documented in Assembly Matrix*
  - ◆ *Updated every six months*
    - *Each update includes flights from date of electronic delivery (VMDB and EDMS) through Assembly Complete*
      - *Delivery broken out into Volumes I & II, plots, line/shaded drawings, and mass properties reports*
  - ◆ *Collaborate with Boeing ISS Mass Properties & Assembly Integration team for mass properties data*
  - ◆ *Primary customer is GN&C (develop PPLs for CMGs)*
- **Additional Aerodynamic and Mass Properties not reflected in Blue Book deliveries**
  - ◆ *Real-time anomaly resolution*
  - ◆ *Requests for data based on updated configurations*





## *Products (Cont'd)*

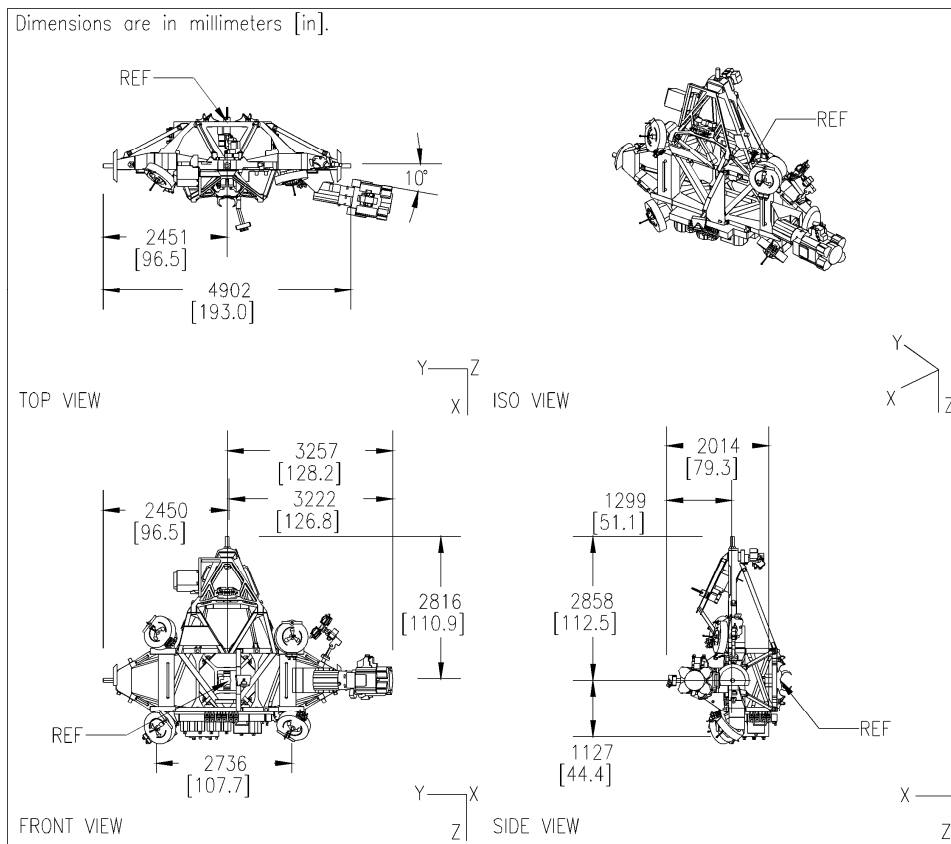
- ***ISS Reference Coordinate System Document (SSP 30219)***
  - ◆ *Contains definitions of coordinate systems used throughout the ISS program*
  - ◆ *Defines coordinate systems such as:*
    - *SSACS (Space Station Analysis Coordinate System)*
    - *Orbiter Structural Coordinate System*
    - *Local origins of external ISS components (e.g. - truss segments, solar array wings, robotic interfaces)*



# Products (Cont'd)

- **4-view drawings containing dimensions of hardware**
  - ◆ Available 4-views are located in the ISS Reference Coordinate System document and Blue Book (Pro/E)

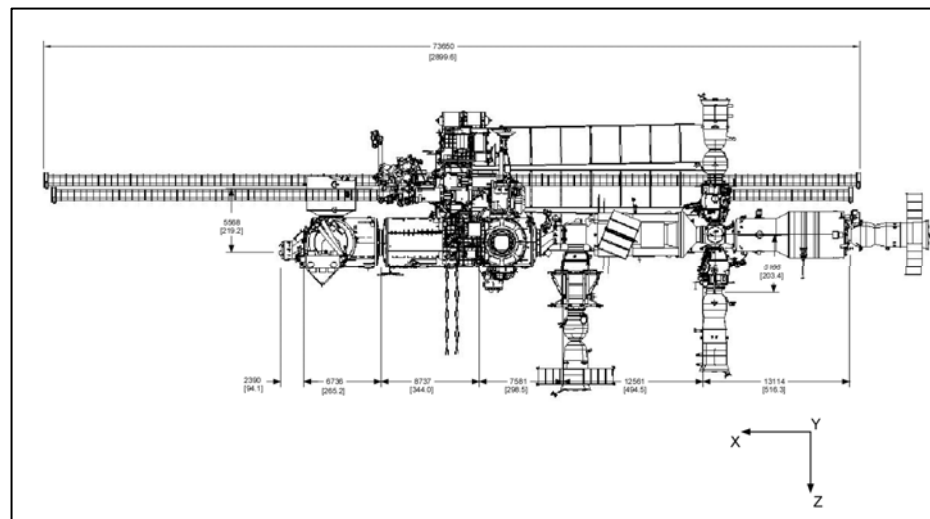
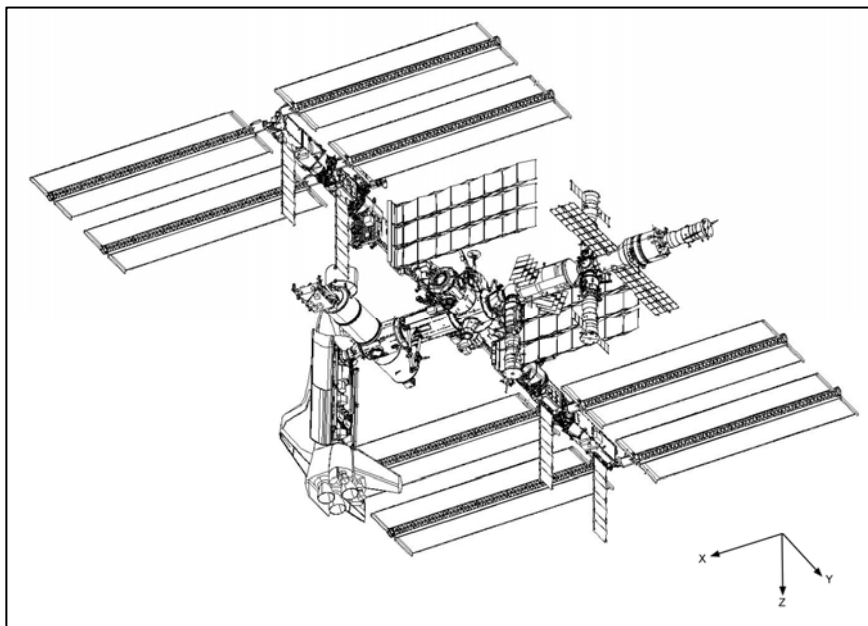
## Product Sample: 4-view Drawing





## Products (Cont'd)

- **ISS On-Orbit ICD (Section 3.0) / VC JTWG Data Source Letters and Orbiter**
  - ◆ Orbiter/ISS On-Orbit ICD define the interfaces between the Orbiter and the International Space Station during proximity and mated operations
  - ◆ Data Source Letters are memos issued at L-9 and L-4 month for each Shuttle flight listing documents associated with Orbiter and ISS configuration data for the joint flight phases
- **Figures showing Orbiter/ISS configuration as well as ISS overall dimensions (Pro/E)**





## *Products (Cont'd)*

- **ExCATT Report Central - [http://saber.jsc.nasa.gov/team\\_cammp/excatt.php#](http://saber.jsc.nasa.gov/team_cammp/excatt.php#)**
  - ◆ *Web-based tool allowing users to generate flight-event based reports from the latest ExCATT database released to the web*
  - ◆ *Generates several reports for on-orbit hardware lists, on-orbit hardware moves, hardware timeline history*



## Products (Cont'd)

### Report Central View

http://jsc-issprd01.jsc.nasa.gov - ExCATT Report Central: Homer - Microsoft Internet Explorer

### ExCATT Report Central

1 Select A Report To Generate: .....

- ☒ **OnOrbit Hardware List**  
 Locations of external hardware, external ORUs and external payloads at a selected event. Displays when the cargo item was launched and what carrier it was launched on / in (Report covers modules, carriers, hardware)  
 For the Excel Version of this report (Currently being validated by 11A Stage MEWG) created on 10/6/2003 Click [here](#).
- ☐ **OnOrbit Hardware Movement**  
 From / To locations for external hardware moved on orbit during a selected event. (Report covers modules, carriers, hardware)
- ☐ **Docking Port Analysis**  
 Docking ports over a range of events, indicating if ports are open or occupied and, if so, what is occupying them
- ☐ **Timeline History Report**  
 Locations of a selected item over the course of time / events  
 (Report currently covers hardware)
- ☒ **Change Request / Feedback**  
 Click to provide data change requests or other questions to the ExCATT data administrator

2 Select A Dataset: .....

- Historical (1AR - 23P undock) -  
13A Plan

Begin >>

Done Internet